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VERIFICATION OF TRANSLATION

I, Harue UMEZAWA, of c/o Sudo International Patent Office, Shinyo Bldg. 6F, 6-1, Nihonbashi-Muromachi 1-chome, Chuo-ku, Tokyo 103-0022 JAPAN
am translator of Japanese Patent Application No. 2002-073089 entitled "CHEMICAL REACTOR FOR NITROGEN OXIDE REMOVAL AND METHOD OF REMOVING NITROGEN OXIDE" and I state that the following is an accurate translation to the best of my knowledge and belief.

(Signature of Translator) Harue Umezawa

(Dated) November 13, 2009

【Name of Document】 Description

【Title of Invention】 CHEMICAL REACTOR FOR NITROGEN OXIDE REMOVAL AND METHOD OF REMOVING NITROGEN OXIDE

【Claims】

【Claim 1】 A chemical reactor for nitrogen oxide emission control, comprising a electrochemical cell with a four-layer structure consisting of an upper cathode (catalyst reaction component) and a lower cathode (positive electrode) composed of an electron-conductive substance and an ion-conductive substance, a solid electrolyte having oxygen ion conductivity, and an anode (negative electrode), wherein the volumetric ratio of the electron-conductive substance and ion-conductive substance that make up the upper cathode is from 3:7 to 7:3.

【Claim 2】 The chemical reactor according to Claim 1, wherein the volumetric ratio of the electron-conductive substance and ion-conductive substance that make up the upper cathode is from 3:7 to 5:5.

【Claim 3】 The chemical reactor according to Claim 1, wherein the volumetric ratio the particles of the electron-conductive substance and the particles of the ion-conductive substance that make up the upper cathode are dispersed each other uniformly.

【Claim 4】 The chemical reactor according to Claim 1 or 2, wherein the electron-conductive substance of the upper cathode is composed of nickel and nickel oxide, and the ion-conductive substance is composed of zirconia stabilized with yttrium oxide or scandium oxide.

【Claim 5】 The chemical reactor according to Claim 1, wherein the electron-conductive substance of the lower cathode is composed of platinum and/or palladium, and the ion-conductive substance is composed of zirconia stabilized with yttrium oxide or scandium oxide.

【Claim 6】 The chemical reactor according to Claim 1, wherein the solid electrolyte is composed of zirconia stabilized with yttrium oxide or scandium oxide.

【Claim 7】 The chemical reactor according to Claim 1, wherein the anode is composed of an electron-conductive substance and an ion-conductive substance, and the volumetric ratio of the electron-conductive substance and ion-conductive substance is from 3:7 to 7:3.

【Claim 8】 The chemical reactor according to Claim 7, wherein the electron-conductive substance of the anode is composed of platinum and/or palladium, and the ion-conductive substance is composed of zirconia stabilized with yttrium oxide or scandium oxide.

【Claim 9】 A method for the emission control of nitrogen oxides with the chemical reactor according to any of Claims 1 to 8, wherein nitrogen oxides are emission-controlled at the upper cathode by applying voltage between the lower cathode and the anode of the electrochemical cell.

【Detailed explanation of the invention】

【0001】

【Technical field to which the Invention belongs】

This invention relates to a chemical reactor for nitrogen oxide emission control, and more particularly relates to a chemical reactor for the efficient emission control of nitrogen oxides from a combustion exhaust gas in which there is an excess of oxygen that would hamper a chemical reaction for nitrogen oxide emission control, and to a method for nitrogen oxide emission control by using this chemical reactor.

【0002】

【Prior art】

The emission control of nitrogen oxides generated by gasoline engines is today primarily handled with a three-way catalytic converter. However, since there is an excess of oxygen in the combustion exhaust gas emitted from diesel engines and lean engines that afford better fuel economy,

the adsorption of oxygen at the surface of the three-way catalytic converter results in a sharp drop-off in catalyst activity, to the point that nitrogen oxide emission control becomes impossible.

【0003】

Meanwhile, another approach has been to use solid electrolyte membrane having oxygen ion conductivity, and pass current through this membrane so that the oxygen in the exhaust gas is removed without being adsorbed to the catalyst surface. One system that has been proposed as a catalyst reactor decomposes nitrogen oxides into oxygen and nitrogen and simultaneously removes surface oxygen by applying voltage to a solid electrolyte sandwiched between electrodes.

【0004】

Prior publications here include (1) J. Electrochemical Soc., 122, 869 (1975), which states that nitrogen oxides are decomposed into nitrogen and oxygen by applying voltage to platinum electrodes formed on both sides of zirconia that has been stabilized with scandium oxide, and (2) J. Chem. Soc. Faraday Trans., 91, 1995 (1995), which states that nitrogen oxides are decomposed into nitrogen and oxygen in a mixed gas of nitrogen oxide, hydrocarbon, and oxygen by applying voltage to palladium electrodes formed on both

sides of zirconia that has been stabilized with yttrium oxide.

【0005】

With the above conventional methods, however, if an excess of oxygen is present in the combustion exhaust gas, the oxygen will be preferentially ionized at the electrodes and flow through the solid electrolyte, so a larger amount of current is required in order to decompose the nitrogen oxides, which means that a higher voltage has to be applied and power consumption is higher, and this poses a major obstacle to practical use.

【0006】

【Subject to be solved by the invention】

In view of this, and in an effort to solve the above problems, the inventors conducted research aimed at developing technology for reducing the amount of oxygen that is ionized at the cathode of an electrochemical cell, even when an excess of oxygen is present in a combustion exhaust gas, and thereby developing technology for decreasing the resistance of an electrochemical cell and at the same time reducing the amount of current needed to decompose nitrogen oxides, and reducing the applied voltage. Specifically, it is an object of the present invention to provide a chemical

reactor with which the amount of current required to decompose nitrogen oxides is reduced by decreasing the amount of oxygen that is ionized and flows through an electrochemical cell, even when there is an excess of oxygen present in a combustion exhaust gas, and the resistance of the electrochemical cell is also lowered, which allows the applied voltage to be reduced and nitrogen oxide emission control to be performed at higher efficiency and lower power consumption.

【0007】

【Means for solving the subject】

The present invention for solving the above subject is constituted from the following technical means.

(1) A chemical reactor for nitrogen oxide emission control, comprising a electrochemical cell with a four-layer structure consisting of an upper cathode (catalyst reaction component) and a lower cathode (positive electrode) composed of an electron-conductive substance and an ion-conductive substance, a solid electrolyte having oxygen ion conductivity, and an anode (negative electrode), wherein the volumetric ratio of the electron-conductive substance and ion-conductive substance that make up the upper cathode is from 3:7 to 7:3.

(2) The chemical reactor according to (1) above, wherein the volumetric ratio of the electron-conductive substance and ion-conductive substance that make up the upper cathode is from 3:7 to 5:5.

(3) The chemical reactor according to (1) above, wherein the volumetric ratio the particles of the electron-conductive substance and the particles of the ion-conductive substance that make up the upper cathode are dispersed each other uniformly.

(4) The chemical reactor according to (1) or (2) above, wherein the electron-conductive substance of the upper cathode is composed of nickel and nickel oxide, and the ion-conductive substance is composed of zirconia stabilized with yttrium oxide or scandium oxide.

(5) The chemical reactor according to (1) above, wherein the electron-conductive substance of the lower cathode is composed of platinum and/or palladium, and the ion-conductive substance is composed of zirconia stabilized with yttrium oxide or scandium oxide.

(6) The chemical reactor according to (1) above, wherein the solid electrolyte is composed of zirconia stabilized with yttrium oxide or scandium oxide.

(7) The chemical reactor according to (1) above, wherein the anode is composed of an electron-conductive substance and an

ion-conductive substance, and the volumetric ratio of the electron-conductive substance and ion-conductive substance is from 3:7 to 7:3.

(8) The chemical reactor according to (7) above, wherein the electron-conductive substance of the anode is composed of platinum and/or palladium, and the ion-conductive substance is composed of zirconia stabilized with yttrium oxide or scandium oxide.

(9) A method for the emission control of nitrogen oxides with the chemical reactor according to any of (1) to (8) above, wherein nitrogen oxides are emission-controlled at the upper cathode by applying voltage between the lower cathode and the anode of the electrochemical cell.

【0008】

【Form of enforcement of the invention】

The present invention will now be described in detail.

The present invention is a chemical reactor for nitrogen oxide emission control, with this chemical reactor being characterized in the composition of the constituent materials of the electrochemical cell that makes up the chemical reactor. The present invention was conceived on the basis of new knowledge discovered by the inventors, namely, that by setting the compositional ratio of the electron-conductive substance and ion-conductive substance

that are the constituent materials of the upper cathode (catalyst reaction component) in the above-mentioned chemical reactor to within a specific range, 1) the nitrogen oxide emission control rate increases critically, and 2) this allows for a large decrease in power consumption and applied voltage. Specifically, in the present invention, the volumetric ratio of the electron-conductive substance and ion-conductive substance that make up the upper cathode is selected from a range of 3:7 to 7:3, and preferably 3:7 to 5:5, the result of which is that there is a specific increase in the nitrogen oxide emission control rate, power consumption is reduced, and there is a decrease in the resistance of the chemical reactor, leading to a reduction in applied voltage. Thus, the present invention was developed on the basis of the new discovery that the nitrogen oxide emission control rate is specifically increased by selecting the constituent materials of the electrochemical cell that makes up the above-mentioned chemical reactor so that the compositional ratio of the constituent materials of the upper cathode (catalyst reaction component) is within a specific ratio.

【0009】

Examples of the electron-conductive substance used for the upper cathode include gold, silver, platinum, palladium,

nickel, and other such metals, and cobalt oxide, nickel oxide, copper oxide, lanthanum chromite, lanthanum manganite, lanthanum cobaltite, and other such metal oxides. An oxygen ion-conductive substance can be used preferably as the ion-conductive substance. The oxygen ion-conductive substance can be zirconia stabilized with yttrium oxide or scandium oxide, ceria stabilized with gadolinium oxide or samarium oxide, lanthanum gallate, or the like. The use of nickel oxide and nickel as the electron-conductive substance is preferable for such reasons as the thermal stability of the chemical reactor during heat treatment, no chemical reaction with the ion-conductive substance, and the ability to decompose nitrogen oxide (the type of gas being treated) at high efficiency. Nickel oxide alone may be used as the electron-conductive substance, but using a mixture of nickel oxide and nickel as the electron-conductive substance is preferable because nitrogen oxides can be decomposed more efficiently. Zirconia that has been stabilized with yttrium oxide or scandium oxide is preferable as the ion-conductive substance because of its excellent electrical and chemical long-term stability.

【0010】

The ratio between the electron-conductive substance and the ion-conductive substance used for the upper cathode, as

the volumetric proportion of the electron-conductive substance, is preferably at least 30% and no more than 70% because, as will be shown in the examples below, the chemical reactor will be able to perform nitrogen oxide emission control more efficiently, and power consumption can be reduced. It is also preferable for the particles of electron-conductive substance and ion-conductive substance to be uniformly dispersed among each other. If the proportion of electron-conductive substance is less than 30%, particles composed of the electron-conductive substance will not be able to come into contact with each other, instead remaining isolated, and this will decrease electron conductivity. If the proportion of electron-conductive substance is over 70%, good electron conductivity will be ensured, but particles composed of the ion-conductive substance will not be able to come into contact with each other, instead remaining isolated, and this will decrease ion conductivity. For nitrogen oxides to be decomposed at high efficiency, the reaction that supplies electrons to the adsorbed nitrogen oxides and ionizes the oxygen atoms, and the reaction that removes the ionized oxygen ions from the adsorption component must proceed smoothly. However, if either the electron conductivity or the ion conductivity decreases, one of these reactions will become rate-

determining, making it impossible to decompose nitrogen oxides at high efficiency. If the proportion of electron-conductive substance is at least 30% and no more than 70%, and if the particles are uniformly dispersed in the lower cathode, particles composed of the electron-conductive substance will be able to come into contact with each other, and particles composed of the ion-conductive substance will also be able to come into contact with each other, so there will be no decrease in either electron conductivity or ion conductivity, making possible the highly efficient decomposition of nitrogen oxides, and allowing power consumption to be reduced. If the volumetric proportion of the electron-conductive substance is 50% or less, as shown in the examples below, there will be a particular decrease in the resistance of the chemical reactor, and less applied voltage will be required for nitrogen oxide emission control. Therefore, it is even more preferable for the volumetric proportion of the electron-conductive substance to be more than 30% and less than 50%.

【0011】

Examples of the electron-conductive substance used for the lower cathode include gold, silver, platinum, palladium, nickel, and other such metals, and cobalt oxide, nickel oxide, copper oxide, lanthanum chromite, lanthanum manganite,

lanthanum cobaltite, and other such metal oxides. An oxygen ion-conductive substance can be used preferably as the ion-conductive substance. The oxygen ion-conductive substance can be zirconia stabilized with yttrium oxide or scandium oxide, ceria stabilized with gadolinium oxide or samarium oxide, lanthanum gallate, or the like. The use of platinum and palladium as the electron-conductive substance is preferable for such reasons as the thermal stability of the chemical reactor during heat treatment, and no chemical reaction with the ion-conductive substance. Zirconia that has been stabilized with yttrium oxide or scandium oxide is preferable as the ion-conductive substance because of its excellent electrical and chemical long-term stability.

【0012】

Any solid electrolyte can be used as long as it has oxygen ion conductivity. There are no particular restrictions on the solid electrolytes with oxygen ion conductivity, but examples include zirconia stabilized with yttrium oxide or scandium oxide, ceria stabilized with gadolinium oxide or samarium oxide, and lanthanum gallate. Of these, zirconia stabilized with yttrium oxide or scandium oxide is preferable because it has high oxygen ion conductivity and mechanical strength and has excellent chemical and electrical long-term stability.

【0013】

Examples of the electron-conductive substance used for the anode include gold, silver, platinum, palladium, nickel, and other such metals, and cobalt oxide, nickel oxide, copper oxide, lanthanum chromite, lanthanum manganite, lanthanum cobaltite, and other such metal oxides. An oxygen ion-conductive substance can be used preferably as the ion-conductive substance. The oxygen ion-conductive substance can be zirconia stabilized with yttrium oxide or scandium oxide, ceria stabilized with gadolinium oxide or samarium oxide, lanthanum gallate, or the like. The use of platinum and palladium as the electron-conductive substance is preferable for such reasons as the thermal stability of the chemical reactor during heat treatment, and no chemical reaction with the ion-conductive substance. Zirconia that has been stabilized with yttrium oxide or scandium oxide is preferable as the ion-conductive substance because of its excellent electrical and chemical long-term stability.

【0014】

The ratio between the electron-conductive substance and the ion-conductive substance used for the anode, as the volumetric proportion of the electron-conductive substance, is preferably at least 30% and no more than 70% because the resistance of the chemical reactor can be decreased this way.

It is also preferable for the particles of electron-conductive substance and ion-conductive substance to be uniformly dispersed among each other. If the proportion of electron-conductive substance is less than 30%, particles composed of the electron-conductive substance will not be able to come into contact with each other, instead remaining isolated, and electrons supplied from the outside cannot be uniformly supplied to the entire anode, so electron conductivity will decrease and the resistance of the chemical reactor will increase. If the proportion of electron-conductive substance is over 70%, electrons supplied from the outside can be uniformly supplied to the entire anode, but particles composed of the ion-conductive substance will not be able to come into contact with each other, instead remaining isolated, so the oxygen ions produced in the decomposition of the nitrogen oxides cannot be uniformly supplied to the solid electrolyte, which means that electron conductivity will decrease and the resistance of the chemical reactor will increase. If the proportion of electron-conductive substance is at least 30% and no more than 70%, and if the particles are uniformly dispersed in the anode, particles composed of the electron-conductive substance will be able to come into contact with each other, and particles composed of the ion-conductive substance will

also be able to come into contact with each other, making it possible for both electrons and oxygen ions to be uniformly dispersed in the entire anode, so there will be no decrease in either electron conductivity or ion conductivity.

【0015】

As to the method for forming the chemical reactor, when a solid electrolyte is used as a substrate, a method can be employed in which a paste or solution containing the substances that make up the upper cathode, lower cathode, and anode is first prepared, a film of each paste is formed on the substrate by screen printing or coating, and this product is baked. To give as an example a case in which a chemical reactor is formed by screen printing using a flat solid electrolyte substrate, first, a paste containing the substances that make up the lower cathode is applied by screen printing over the solid electrolyte substrate, and then baked. Next, a paste containing the substances that make up the upper cathode is applied by screen printing so as to cover the previously formed lower cathode, and this product is again baked. Finally, a paste containing the substances that make up the anode is applied by screen printing to the other side of the solid electrolyte substrate and baked, which forms a chemical reactor. The method for forming the films is not limited to screen

printing and coating, and may instead be a method in which solutions containing the substances that make up the various layers are prepared, and films are formed on the substrate by dip coating or spin coating. Films can also be formed by PVD or CVD. The solid electrolyte is not the only component that can be used as the substrate, and as long as they have enough mechanical strength that they will not be damaged in the process of forming the chemical reactor, the upper cathode, lower cathode, or anode can also be used as the substrate. Also, sheets containing the substances that make up the upper cathode, lower cathode, solid electrolyte, and anode can be produced by a sheet forming method, and these sheets can be joined by compression bonding and baked, allowing a chemical reactor to be formed without the use of a substrate. Of these methods, one in which a solid electrolyte is used as a substrate, pastes containing the various constituent substances are prepared, films are formed by screen printing or coating, and these films are baked, can be used to advantage in that the equipment used is relatively inexpensive, and films can be formed easily, for example.

【0016】

Examples of suitable forms for the chemical reactor of the present invention include that of a flat sheet, a

cylinder, and a honeycomb. In the case of a flat sheet, exhaust gas can be purified by laminating the upper cathode, lower cathode, solid electrolyte, and anode to form a chemical reactor, and disposing the upper cathode so that it comes into contact with the exhaust gas. In the case of a cylinder, when the chemical reactor is formed such that the inside of the cylinder is the lower cathode and the outside is the anode, exhaust gas can be purified by allowing the exhaust gas to pass through the inside of the cylinder. Conversely, when the chemical reactor is formed such that the outside of the cylinder is the lower cathode and the inside is the anode, exhaust gas can be purified by allowing the exhaust gas to pass over the outside of the cylinder. This chemical reactor is not limited to being used by itself, and disposing a plurality of chemical reactors in series, in parallel, or in series and parallel with respect to the flow of the gas is favorable in that a larger amount of nitrogen oxides can be decomposed.

【0017】

A chemical reactor produced in this manner is disposed so that the upper cathode will come into contact with exhaust gas containing nitrogen oxides, leads taken off from the lower cathode and the anode are connected to an external power supply, and DC voltage is applied, which causes the

oxygen ions produced in the decomposition of the nitrogen oxide at the upper cathode to move through the lower cathode and the solid electrolyte to the anode, and these oxygen ions are converted into oxygen molecules at the anode, allowing the nitrogen oxides in the exhaust gas to be efficiently decomposed. Voltage is not applied directly to the upper cathode, but external voltage causes the oxygen ions to move from the lower cathode to the solid electrolyte, this lowers the oxygen concentration near the interface between the upper cathode and lower cathode, and an oxygen concentration differential is produced near the interface between the lower cathode and the outer surface of the upper cathode in contact with the exhaust gas, so there is movement of the oxygen ions from the outer surface of the upper cathode to the area near the lower cathode interface so as to compensate for this oxygen concentration differential, and as a result the oxygen ions produced in the decomposition of the nitrogen oxides at the upper cathode go from the lower cathode through the solid electrolyte and the anode and are converted into oxygen molecules.

【0018】

【Examples】

Examples of the present invention will now be described through reference to the drawings. Fig. 1 is a cross section of a flat chemical reactor pertaining to an embodiment of the present invention. A lower cathode 2 and an upper cathode 1 are formed on one side of a solid electrolyte 3 having oxygen ion conductivity, and an anode 4 is formed on the other side. The lower cathode 2 is disposed between the solid electrolyte 3 and the upper cathode 1 so as to be in contact with both the solid electrolyte 3 and the upper cathode 1. Figs. 2 and 3 are cross sections of a cylindrical chemical reactor pertaining to an embodiment of the present invention. In Fig. 2, the lower cathode 2 and the upper cathode 1 are formed around the inner peripheral surface of a cylindrical solid electrolyte 3 having oxygen ion conductivity, and the anode 4 is formed around the outer peripheral surface. The lower cathode 2 is disposed between the solid electrolyte 3 and the upper cathode 1 so as to be in contact with both the solid electrolyte 3 and the upper cathode 1. In Fig. 3, the lower cathode 2 and the upper cathode 1 are formed around the outer peripheral surface of a cylindrical solid electrolyte 3 having oxygen ion conductivity, and the anode 4 is formed around the inner peripheral surface. The lower cathode 2 is disposed between the solid electrolyte 3 and

the upper cathode 1 so as to be in contact with both the solid electrolyte 3 and the upper cathode 1. Regardless of whether the chemical reactor is flat or cylindrical in shape, the upper cathode is disposed so as to come into contact with an exhaust gas containing nitrogen oxides. Leads are taken out from the lower cathode and the anode and connected to an external power supply, DC and voltage is applied so that there will be a negative potential on the lower cathode side and a positive potential on the anode side, which results in the nitrogen oxides being decomposed at the upper cathode.

【0019】

Example 1

Zirconia stabilized with yttrium oxide was used as the solid electrolyte 3 having ion conductivity, and the shape thereof was that of a disk with a diameter of 20 mm and a thickness of 0.5 mm. The lower cathode 2 was formed by first producing a paste by adding an organic solvent to a mixed powder of an electron-conductive substance composed of platinum and an ion-conductive substance composed of zirconia stabilized with yttrium oxide, with the mixing ratio (volumetric ratio) being 60:40, and then applying this paste by screen printing to one side of the solid electrolyte 3 such that the surface area was approximately

1.8 cm^2, and then heat treating this product at 1200°C. The upper cathode 1 was formed by first producing a paste by adding an organic solvent to a mixed powder of an electron-conductive substance composed of nickel oxide and nickel and an ion-conductive substance composed of zirconia stabilized with yttrium oxide, with the mixing ratio (volumetric ratio) being 30.5:69.5, and then applying this paste by screen printing over the lower cathode 2 in the same surface area as the lower cathode, and then heat treating this product at 1500°C. The anode 4 was formed by first producing a paste by adding an organic solvent to a mixed powder of an electron-conductive substance composed of platinum and an ion-conductive substance composed of zirconia stabilized with yttrium oxide, with the mixing ratio (volumetric ratio) being 60:40, and then applying this paste by screen printing to the other side of the solid electrolyte 3 on which the upper cathode 1 and the lower cathode 2 are formed, such that the surface area was approximately 1.8 cm^2, and then heat treating this product at 1200°C. This resulted in a chemical reactor.

【0020】

The method for nitrogen oxide emission control using the chemical reactor of the present invention formed in this

manner will now be described. The chemical reactor was disposed in a treatment gas, platinum wires were fixed as lead wires to the lower cathode 2 and the anode 4, these leads were connected to a DC power supply, and DC voltage was applied so that current passed through. The nitrogen oxide decomposition and emission control characteristics were evaluated at temperatures between 600 and 650°C. As the treatment gas, a model combustion exhaust gas composed of 1000 ppm nitrogen monoxide and the balance helium containing 3% oxygen was introduced at a flow rate of 50 mL/min. The nitrogen oxide concentration in the treatment gas before and after the model combustion exhaust gas passed through the chemical reactor was measured with a chemiluminescence type of NOx meter, the nitrogen and oxygen concentrations were measured by gas chromatography, and the nitrogen oxide emission control rate was calculated from the reduction in nitrogen oxides. Table 1 shows the nitrogen oxide emission control rate when the chemical reactor was heated to 650°C and 0.4 W of electric power was applied, and the nitrogen oxide emission control rate when the chemical reactor was heated to 650°C and 600°C and a voltage of 2.25 V was applied.

【0021】

Example 2

A chemical reactor was produced in the same manner as in Example 1, except that the mixing ratio (volumetric ratio) of the electron-conductive substance and ion-conductive substance of the upper cathode 1 was changed to 35.0:65.0. The nitrogen oxide emission control characteristics of this chemical reactor were evaluated in the same manner as in Example 1, the results of which are given in Table 1.

【0022】

Example 3

A chemical reactor was produced in the same manner as in Example 1, except that the mixing ratio (volumetric ratio) of the electron-conductive substance and ion-conductive substance of the upper cathode 1 was changed to 44.6:55.4. The nitrogen oxide emission control characteristics of this chemical reactor were evaluated in the same manner as in Example 1, the results of which are given in Table 1.

【0023】

Example 4

A chemical reactor was produced in the same manner as in Example 1, except that the mixing ratio (volumetric ratio) of the electron-conductive substance and ion-

conductive substance of the upper cathode 1 was changed to 55.6:44.4. The nitrogen oxide emission control characteristics of this chemical reactor were evaluated in the same manner as in Example 1, the results of which are given in Table 1.

【0024】

Example 5

A chemical reactor was produced in the same manner as in Example 1, except that the mixing ratio (volumetric ratio) of the electron-conductive substance and ion-conductive substance of the upper cathode 1 was changed to 69.5:30.5. The nitrogen oxide emission control characteristics of this chemical reactor were evaluated in the same manner as in Example 1, the results of which are given in Table 1.

【0025】

Example 6

Zirconia stabilized with scandium oxide was used as the solid electrolyte 3 having ion conductivity, and the shape thereof was that of a disk with a diameter of 20 mm and a thickness of 0.5 mm. The lower cathode 2 was formed by first producing a paste by adding an organic solvent to a mixed powder of an electron-conductive substance composed of platinum and an ion-conductive substance composed of

zirconia stabilized with scandium oxide, with the mixing ratio (volumetric ratio) being 60:40, and then applying this paste by screen printing to one side of the solid electrolyte 3 such that the surface area was approximately 1.8 cm^2, and then heat treating this product at 1200°C. The upper cathode 1 was formed by first producing a paste by adding an organic solvent to a mixed powder of an electron-conductive substance composed of nickel oxide and nickel and an ion-conductive substance composed of zirconia stabilized with scandium oxide, with the mixing ratio (volumetric ratio) being 35.0:65.0, and then applying this paste by screen printing over the lower cathode 2 in the same surface area as the lower cathode, and then heat treating this product at 1500°C. The anode 4 was formed by first producing a paste by adding an organic solvent to a mixed powder of an electron-conductive substance composed of platinum and an ion-conductive substance composed of zirconia stabilized with scandium oxide, with the mixing ratio (volumetric ratio) being 60:40, and then applying this paste by screen printing to the other side of the solid electrolyte 3 on which the upper cathode 1 and the lower cathode 2 are formed, such that the surface area was approximately 1.8 cm^2, and then heat treating this product at 1200°C. This resulted in a chemical reactor. The

nitrogen oxide emission control characteristics of this chemical reactor were evaluated in the same manner as in Example 1, the results of which are given in Table 1.

【0026】

Comparative Example 1

A chemical reactor was produced in the same manner as in Example 1, except that the mixing ratio (volumetric ratio) of the electron-conductive substance and ion-conductive substance of the upper cathode 1 was changed to 26.5:73.5. The nitrogen oxide emission control characteristics of this chemical reactor were evaluated in the same manner as in Example 1, the results of which are given in Table 1.

【0027】

Comparative Example 2

A chemical reactor was produced in the same manner as in Example 1, except that the mixing ratio (volumetric ratio) of the electron-conductive substance and ion-conductive substance of the upper cathode 1 was changed to 83.6:16.4. The nitrogen oxide emission control characteristics of this chemical reactor were evaluated in the same manner as in Example 1, the results of which are given in Table 1.

【0028】

Comparative Example 3

Zirconia stabilized with yttrium oxide was used as the solid electrolyte 3 having ion conductivity, and the shape thereof was that of a disk with a diameter of 20 mm and a thickness of 0.5 mm. The lower cathode 2 was formed in the same manner as in Example 1. After this, no upper cathode 1 was formed, and the anode 4 was formed in the same manner as in Example 1 on the other side of the solid electrolyte 3 from that where the lower cathode 2 was formed, to produce a chemical reactor. The nitrogen oxide emission control characteristics of this chemical reactor were evaluated in the same manner as in Example 1, the results of which are given in Table 1.

【0029】

Table 1

	Nitrogen oxide emission control rate		
	Operating temp. 650°C Power consumption 0.4 W	Operating temp. 650°C Applied voltage 2.25 V	Operating temp. 600°C Applied voltage 2.25 V
Example 1	41%	66%	42%
Example 2	44%	66%	47%
Example 3	43%	64%	43%
Example 4	41%	53%	36%
Example 5	35%	41%	28%
Example 6	45%	77%	50%
Comp. Ex. 1	28%	32%	24%

Comp. Ex. 2	15%	12%	11%
Comp. Ex. 3	0%	2%	0%

【0030】

【Effect of the invention】

As discussed in detail above, the present invention relates to a chemical reactor for performing nitrogen oxide emission control, and the present invention provides a chemical reactor with which nitrogen oxides can be treated at low power consumption, low applied voltage, and high efficiency, even in the presence of an excess of oxygen that hampers nitrogen oxide emission control, and to a method for performing nitrogen oxide emission control at high efficiency using this chemical reactor.

【Brief description of the drawings】

【Fig. 1】

Fig. 1 is a cross section of a flat chemical reactor pertaining to an embodiment of the present invention;

【Fig. 2】

Fig. 2 is a cross section of a cylindrical chemical reactor pertaining to an embodiment of the present invention;

【Fig. 3】

Fig. 3 is a cross section of another cylindrical chemical reactor pertaining to an embodiment of the present invention;

【Description of symbols】

1 upper cathode

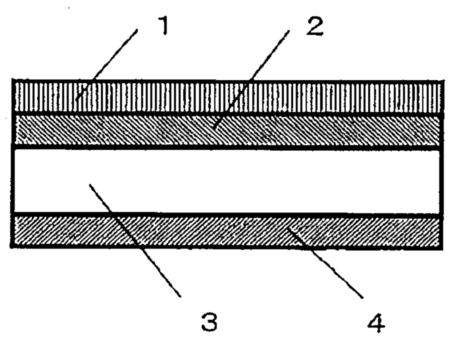
2 lower cathode

3 solid electrolyte

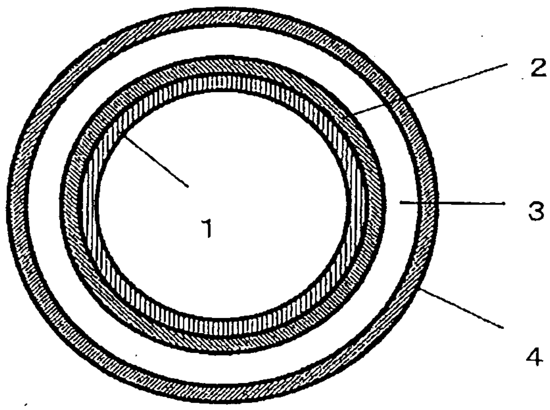
4 anode

【Name of document】 Drawing

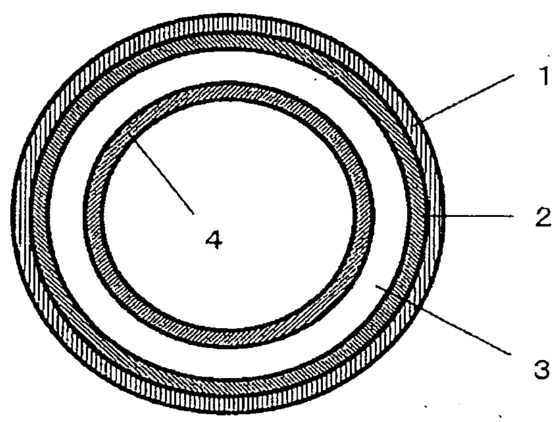
【Fig. 1】



【Fig. 2】



【Fig. 3】



【Name of document】 Abstract

【Summary】

【Subject】 The present invention provides a chemical reactor with which nitrogen oxide emission control can be performed very efficiently at a low applied voltage when an excess of oxygen is present in a combustion exhaust gas.

【Means of solution】 The present invention is a chemical reactor in which the upper cathode, lower cathode, and anode that make the chemical reactor are a mixture of an electron-conductive substance and an ion-conductive substance, and the electron-conductive substance and ion-conductive substance of the upper cathode are mixed in a specific ratio, which makes it possible to lower the applied voltage and reduce the power consumption of the chemical reactor, and is also a method for the emission control of nitrogen oxides in which this chemical reactor is used.

【Figure to be selected】 Fig. 1